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Okajima

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(54) **STORAGE CONTROL APPARATUS, STORAGE CONTROL METHOD, AND COMPUTER-READABLE RECORDING MEDIUM HAVING STORED STORAGE CONTROL PROGRAM**

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G06F 3/06 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/067*** (2013.01); ***G06F 3/0604*** (2013.01); ***G06F 3/0626*** (2013.01); ***G06F 3/0646*** (2013.01); ***G06F 3/0661*** (2013.01); ***G06F 3/0662*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/067; G06F 3/0626; G06F 3/0661; G06F 3/0662; G06F 3/0604; G06F 3/0646
See application file for complete search history.

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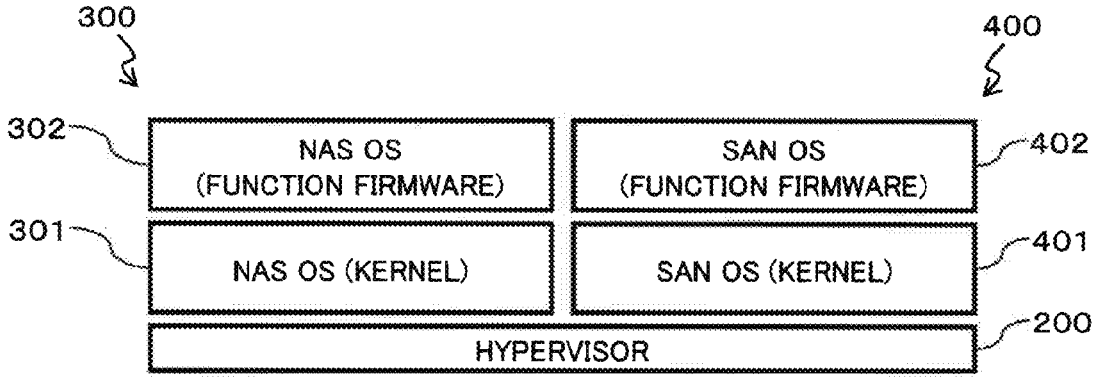
(57) **ABSTRACT**

A storage apparatus includes a processing unit that functions a SAN OS which performs SAN control and a NAS OS which performs NAS control to be operated on a virtualized OS, an inter-OS communication unit that transmits and receives data between the NAS OS and the SAN OS, a transmission controller that transmits a NAS input/output request received in the NAS OS to the SAN OS through the inter-OS communication unit, and a NAS request processing unit that processes the NAS input/output request received from the transmission controller in the SAN OS. With this configuration, the NAS and the SAN can be efficiently integrated in a storage apparatus.

12 Claims, 9 Drawing Sheets



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WO	2006/022161	3/2006

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FIG. 1

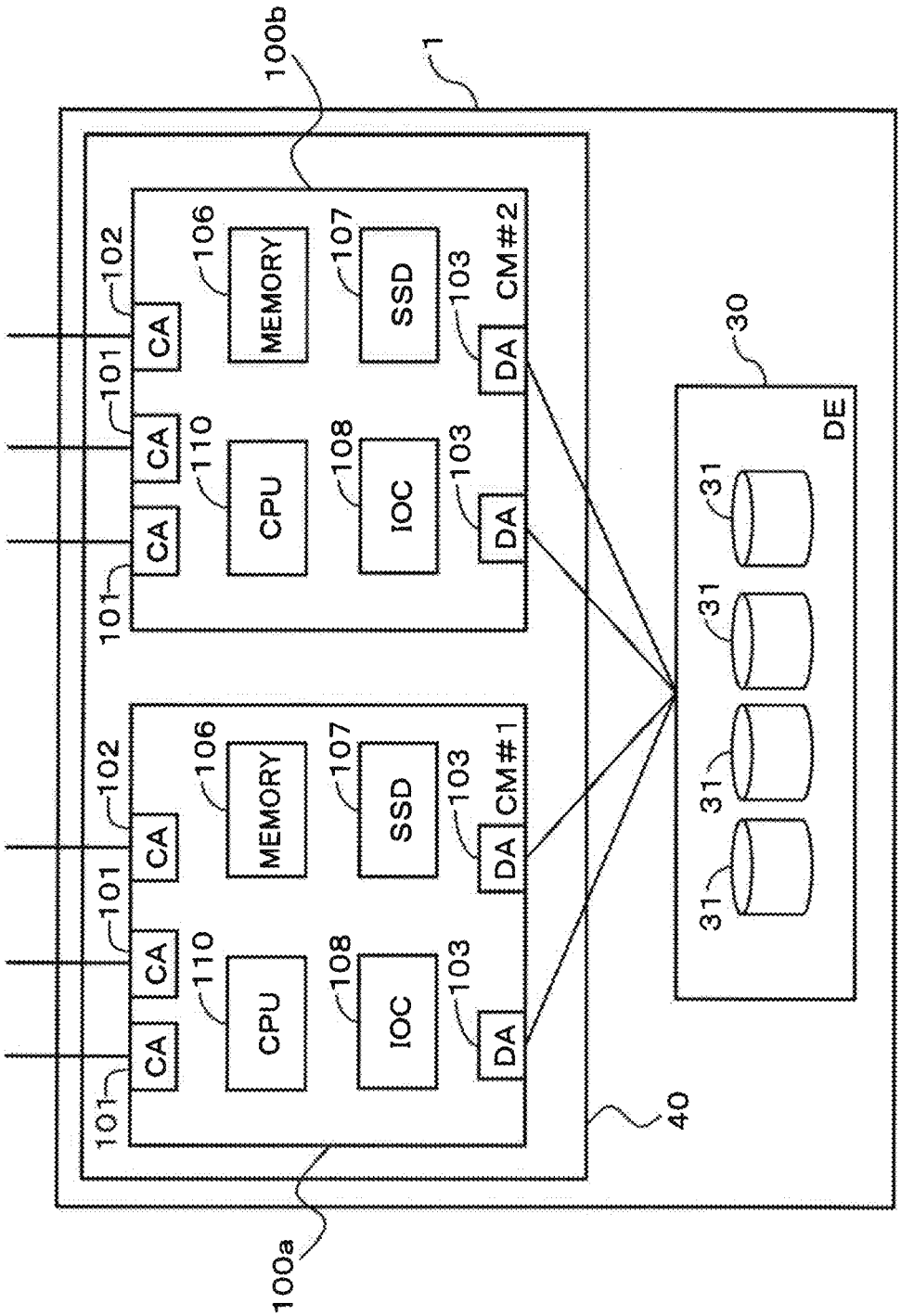

100b
1
102
101
CA
106
MEMORY
107
SSD
103
CM#2
DA
110
CPU
108
IOC
30
DE
31
40
100a
CM#1

FIG. 2

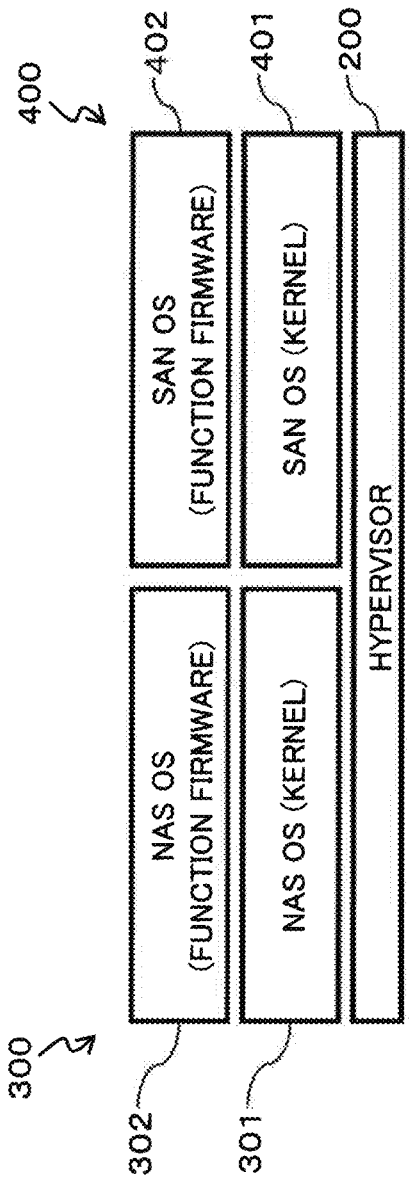

400
402
401
200
SAN OS
(FUNCTION FIRMWARE)
SAN OS (KERNEL)
HYPERVISOR
NAS OS
(FUNCTION FIRMWARE)
NAS OS (KERNEL)
300
302
301

FIG. 3

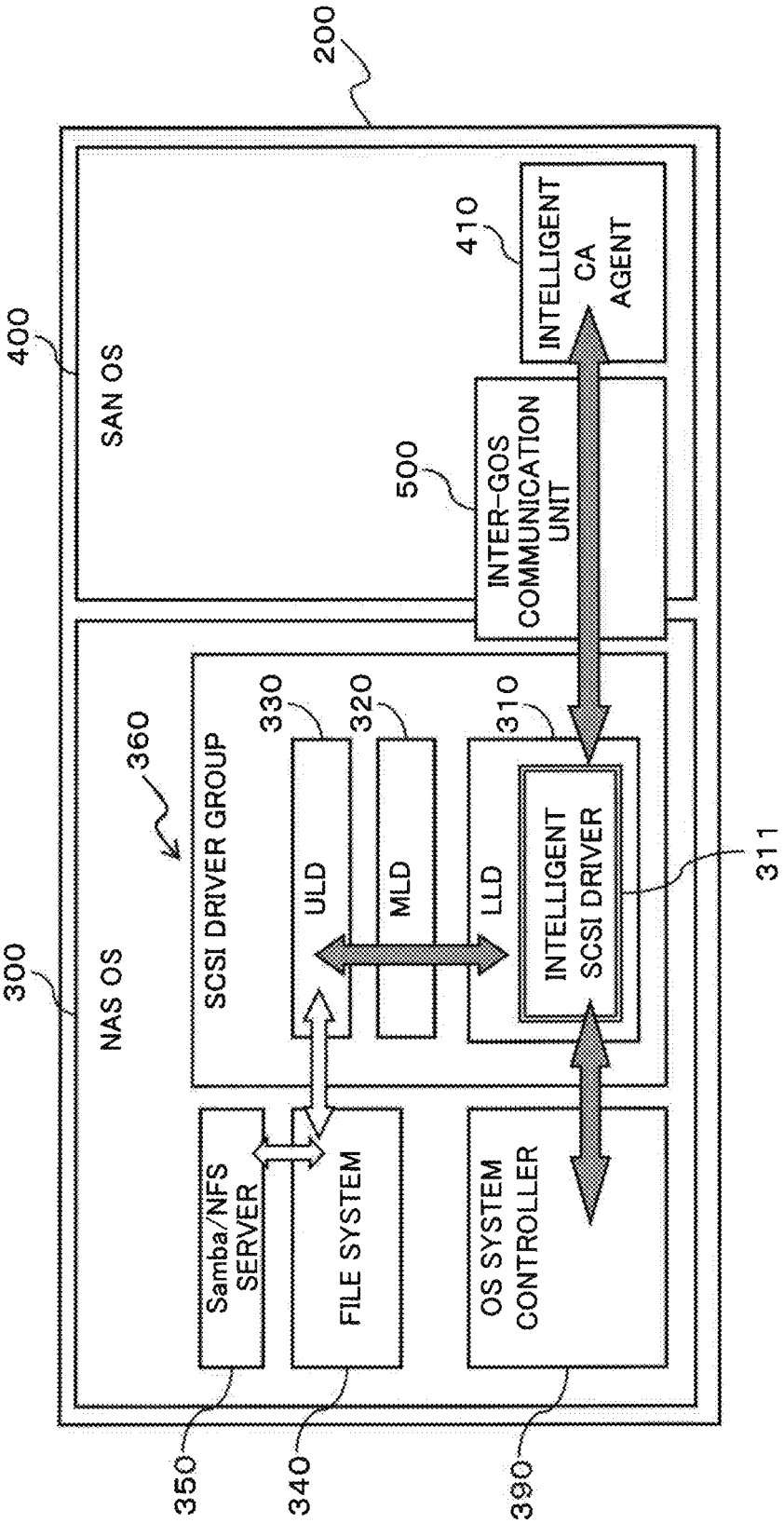

200
400
SAN OS
410
INTELLIGENT CA AGENT
500
INTER-GOS COMMUNICATION UNIT
300
NAS OS
360
SCSI DRIVER GROUP
330
320
310
ULD
MLD
LLD
INTELLIGENT SCSI DRIVER
311
Samba/NFS SERVER
FILE SYSTEM
OS SYSTEM CONTROLLER
350
340
390

FIG. 4

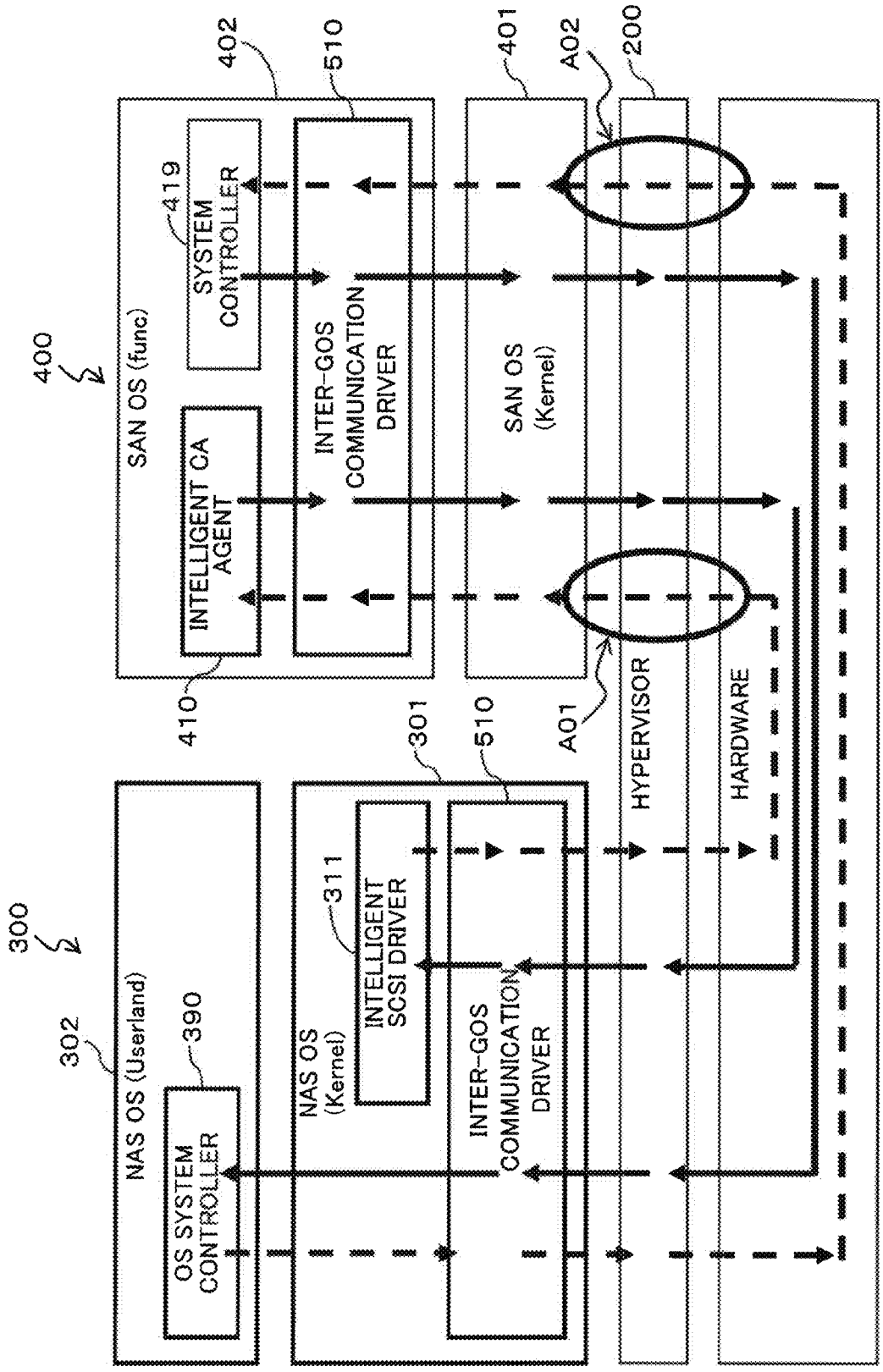

400
SAN OS (func)
402
510
401
A02
200
419
SYSTEM CONTROLLER
INTELLIGENT CA AGENT
INTER-GOS COMMUNICATION DRIVER
SAN OS (Kernel)
410
A01
HYPERVISOR
HARDWARE
300
NAS OS (Userland)
302
390
OS SYSTEM CONTROLLER
NAS OS (Kernel)
311
INTELLIGENT SCSI DRIVER
301
510
INTER-GOS COMMUNICATION DRIVER

FIG. 5

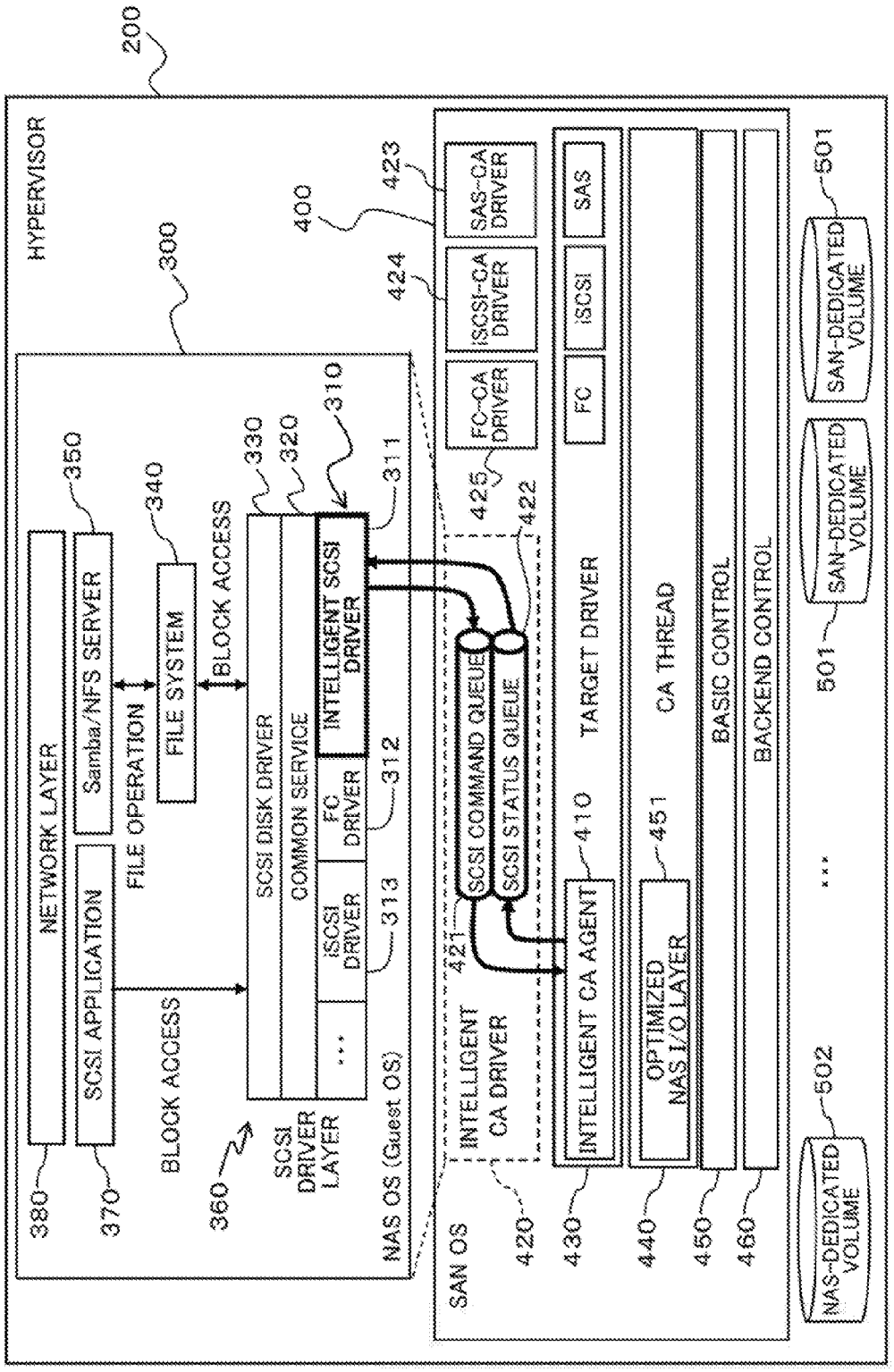

200
HYPERVISOR
300
NETWORK LAYER
380
SCSI APPLICATION
370
Samba/NFS SERVER
350
FILE OPERATION
BLOCK ACCESS
360
FILE SYSTEM
340
BLOCK ACCESS
SCSI DISK DRIVER
330
COMMON SERVICE
320
iSCSI DRIVER
313
FC DRIVER
312
INTELLIGENT SCSI DRIVER
310
311
SCSI DRIVER LAYER
NAS OS (Guest OS)
400
423
424
425
422
FC-CA DRIVER
iSCSI-CA DRIVER
SAS-CA DRIVER
SAN OS
INTELLIGENT CA DRIVER
420
421
SCSI COMMAND QUEUE
SCSI STATUS QUEUE
INTELLIGENT CA AGENT
430
410
TARGET DRIVER
FC
iSCSI
SAS
OPTIMIZED NAS I/O LAYER
440
451
CA THREAD
BASIC CONTROL
450
BACKEND CONTROL
460
...
501
SAN-DEDICATED VOLUME
NAS-DEDICATED VOLUME
502

FIG. 6

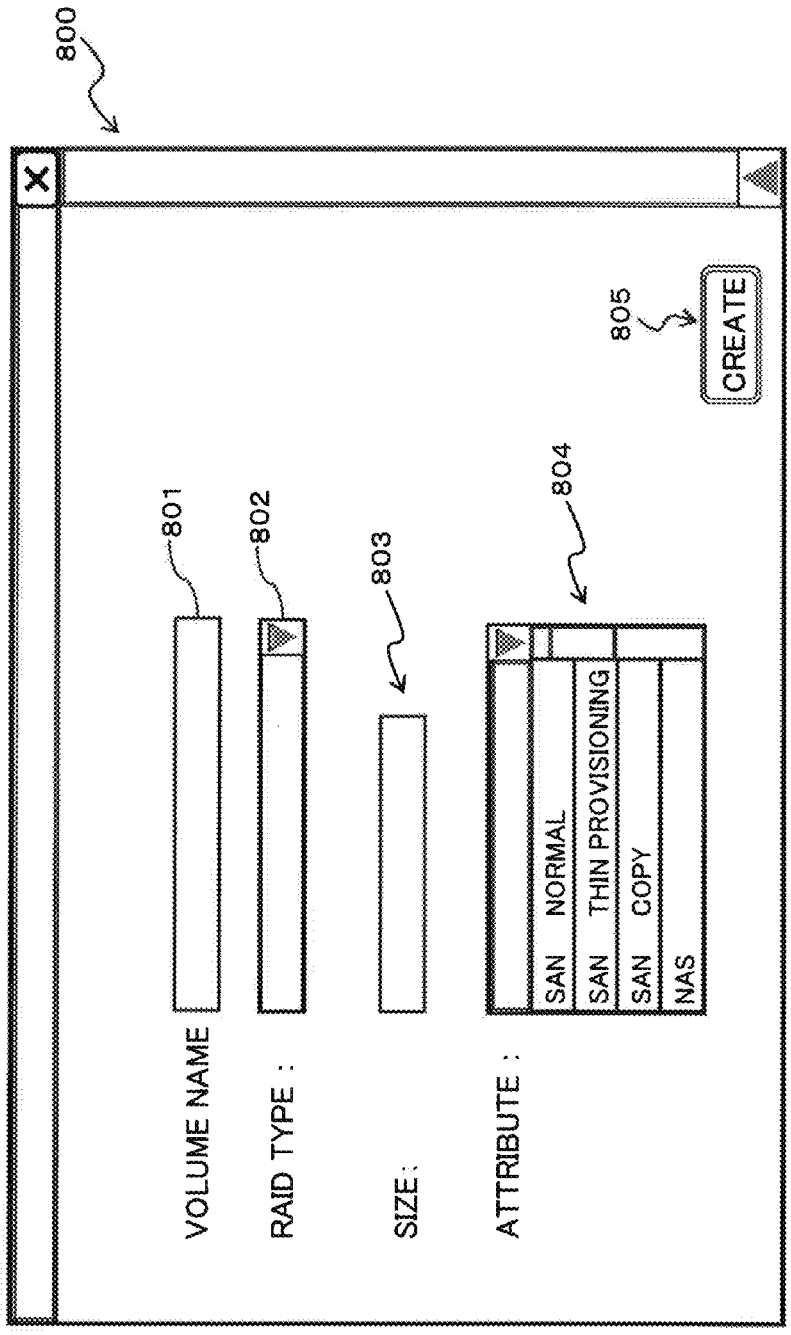

800
801
802
803
804
805
CREATE
VOLUME NAME
RAID TYPE :
SIZE:
ATTRIBUTE :
SAN NORMAL
SAN THIN PROVISIONING
SAN COPY
NAS

FIG. 7

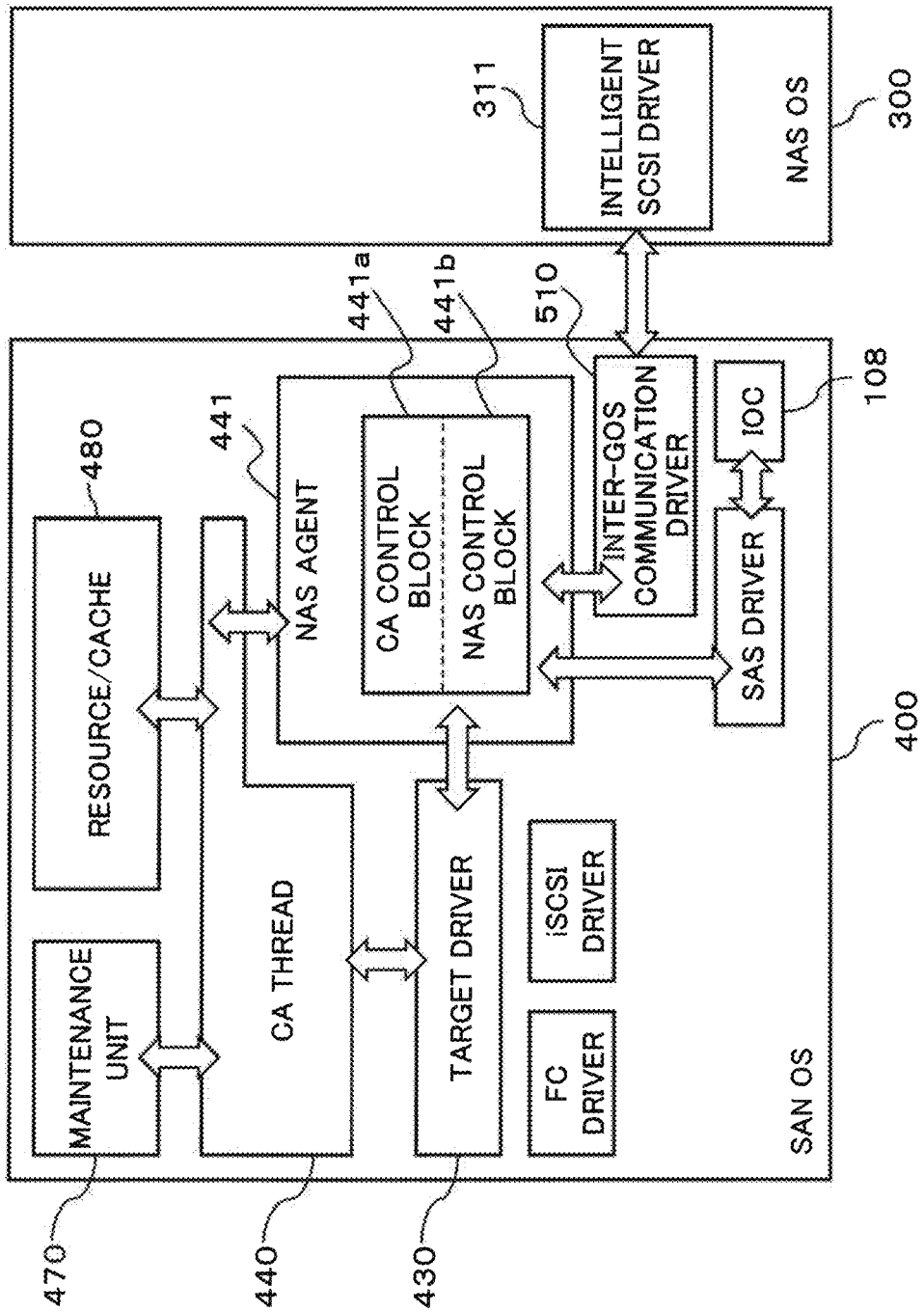

NAS OS
300
311
INTELLIGENT SCSI DRIVER
441a
441b
510
108
480
441
RESOURCE/CACHE
NAS AGENT
CA CONTROL BLOCK
NAS CONTROL BLOCK
INTER-GOS COMMUNICATION DRIVER
IOC
SAS DRIVER
400
MAINTENANCE UNIT
CA THREAD
TARGET DRIVER
iSCSI DRIVER
FC DRIVER
SAN OS
470
440
430

FIG. 8

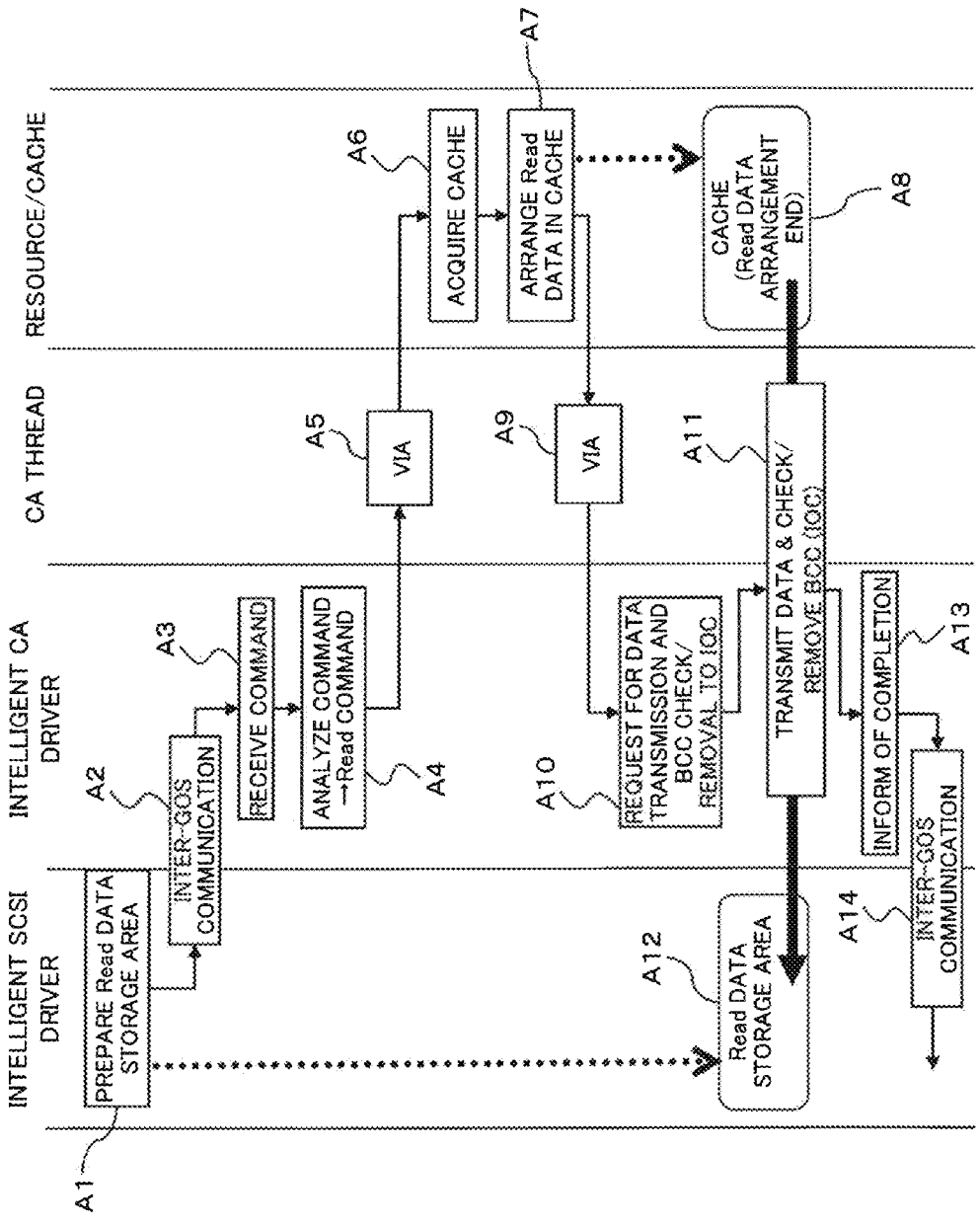
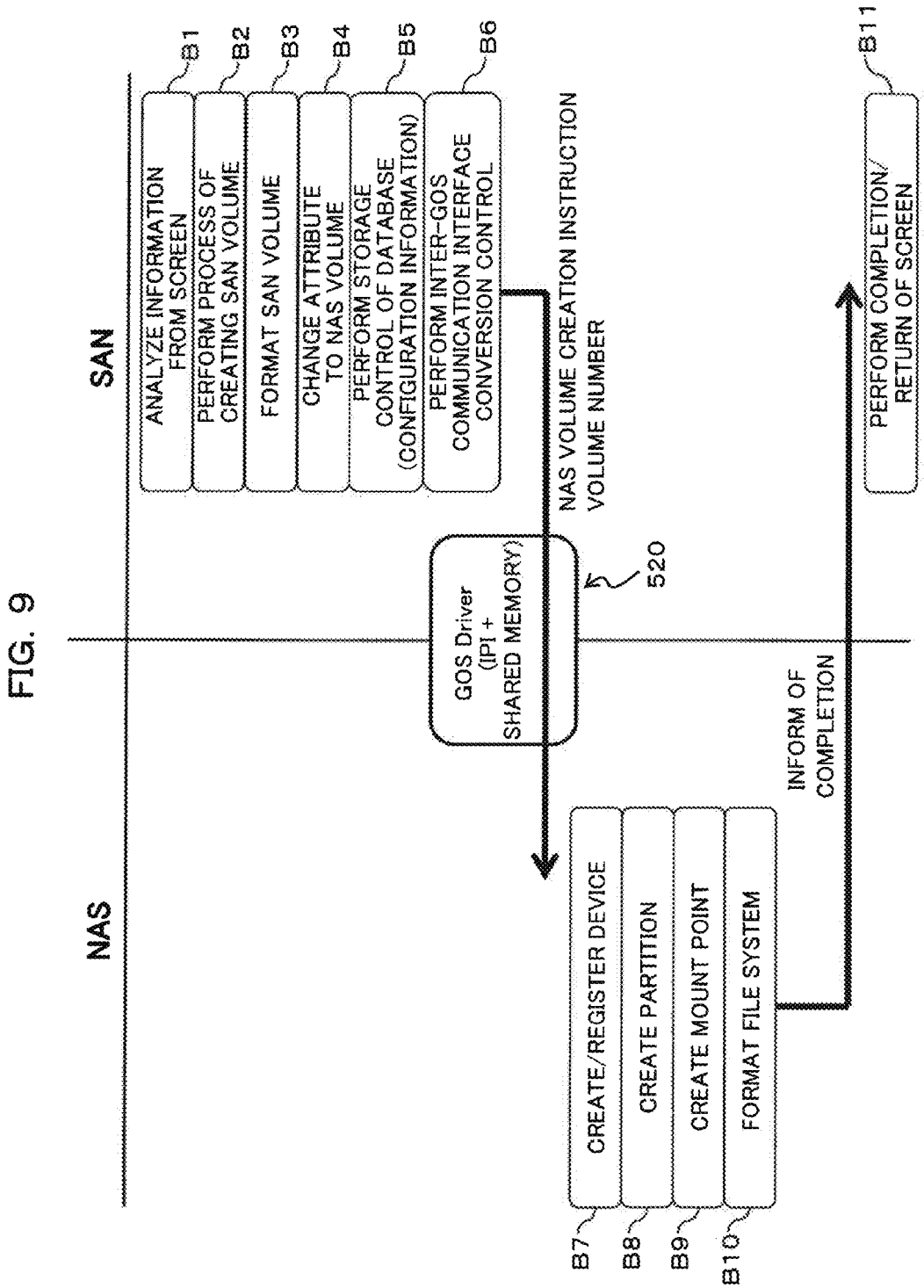

INTELLIGENT SCSI DRIVER
INTELLIGENT CA DRIVER
CA THREAD
RESOURCE/CACHE
A1
PREPARE Read DATA STORAGE AREA
A2
INTER-GOS COMMUNICATION
A3
RECEIVE COMMAND
ANALYZE COMMAND →Read COMMAND
A4
A5
VIA
A6
ACQUIRE CACHE
A7
ARRANGE Read DATA IN CACHE
A8
CACHE (Read DATA ARRANGEMENT END)
A9
VIA
A10
REQUEST FOR DATA TRANSMISSION AND BCC CHECK/ REMOVAL TO IOC
A11
TRANSMIT DATA & CHECK/ REMOVE BCC (IOC)
A12
Read DATA STORAGE AREA
A13
INFORM OF COMPLETION
A14
INTER-GOS COMMUNICATION

FIG. 9


SAN
NAS
B1
ANALYZE INFORMATION FROM SCREEN
B2
PERFORM PROCESS OF CREATING SAN VOLUME
B3
FORMAT SAN VOLUME
B4
CHANGE ATTRIBUTE TO NAS VOLUME
B5
PERFORM STORAGE CONTROL OF DATABASE (CONFIGURATION INFORMATION)
B6
PERFORM INTER-GOS COMMUNICATION INTERFACE CONVERSION CONTROL
GOS Driver (IPI + SHARED MEMORY)
520
NAS VOLUME CREATION INSTRUCTION
VOLUME NUMBER
B7
CREATE/REGISTER DEVICE
B8
CREATE PARTITION
B9
CREATE MOUNT POINT
B10
FORMAT FILE SYSTEM
INFORM OF COMPLETION
B11
PERFORM COMPLETION/ RETURN OF SCREEN

STORAGE CONTROL APPARATUS, STORAGE CONTROL METHOD, AND COMPUTER-READABLE RECORDING MEDIUM HAVING STORED STORAGE CONTROL PROGRAM

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent application No. 2013-202311, filed on Sep. 27, 2013, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are directed to a storage control apparatus, a storage control method, and a storage control program.

BACKGROUND

As a network storage system, a network attached storage (NAS) and a storage area network (SAN) are known.

The NAS which is connected to the existing Internet (registered trademark) network is simple in management compared to the SAN, but degraded in performance and causes capacity insufficiency in many cases. On the other hand, the SAN generally operates at high speed compared to the NAS and can store a large amount of data, but it is expensive in price.

In order to improve the efficiency in data storage and the reduction in cost by combining advantages of the NAS and the SAN, a method of integrating the SAN and the NAS is known, and specifically the SAN and the NAS are integrated by employing a NAS gateway.

Patent Document 1: Japanese Laid-open Patent Publication No. 2004-220216

Patent Document 2: Japanese Laid-open Patent Publication No. 2008-535099

Patent Document 3: International Publication Pamphlet No. WO 2006/022161

However, the storage system in the related art is provided with a server machine for implementing a NAS gateway function in order to integrate the SAN and the NAS. Therefore, there is a problem in that a cost for configuring the system increases.

Further, the network storage system in which the NAS gateway is used to integrate the SAN and the NAS as described above, it is necessary to perform the setting of the SAN and the setting of the NAS separately. Therefore, there is also a problem in that a workload of operations by a manager increases.

SUMMARY

According to an aspect of the embodiments, a storage control apparatus includes a processing unit that functions a SAN operating system which performs SAN control and a NAS operating system (OS), which performs NAS control to be operated on a virtualized operating system, an inter-OS communication unit that transmits and receives data between the NAS operating system and the SAN operating system, a transmission controller that transmits a NAS input/output request received in the NAS operating system to the SAN operating system through the inter-OS communication unit, and a NAS request processing unit that processes the NAS input/output request received from the transmission controller in the SAN operating system.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram schematically illustrating a hardware configuration of a storage apparatus according to an embodiment;

FIG. **2** is a diagram schematically illustrating a plurality of OSs on a hypervisor in the storage apparatus according to the embodiment;

FIG. **3** is a diagram schematically illustrating a functional configuration of a NAS OS and a SAN OS on the hypervisor in the storage apparatus according to the embodiment;

FIG. **4** is a diagram for describing inter-guest OS communication in the storage apparatus according to the embodiment;

FIG. **5** is a diagram illustrating a detailed functional configuration of the NAS OS and the SAN OS on the hypervisor of the storage apparatus according to the embodiment;

FIG. **6** is a diagram illustrating a volume creation screen in the storage apparatus according to the embodiment;

FIG. **7** is a diagram schematically illustrating a functional configuration of the SAN OS in the storage apparatus according to the embodiment;

FIG. **8** is a sequence diagram for describing an exemplary process in the storage apparatus according to the embodiment; and

FIG. **9** is a sequence diagram for describing a creating process of a NAS-dedicated volume in the storage apparatus according to the embodiment.

DESCRIPTION OF EMBODIMENT(S)

Hereinafter, embodiments of a storage control apparatus, a storage control method, and a storage control program will be described with reference to the drawings. However, the following embodiments are given as merely exemplary embodiments, and it is not intended to exclude various modifications and various technical applications which are not specified in the embodiments. In other words, the embodiments can be implemented in various forms within a scope not departing from the spirit thereof. Further, there is no purpose of exclusively including only the components in the drawings, but other functions can be included.

FIG. **1** is a diagram schematically illustrating a hardware configuration of a storage apparatus **1** according to an embodiment.

The storage apparatus **1** virtualizes storage devices **31** which are stored in a drive enclosure (DE) **30** to set up a virtual storage environment. Then, the storage apparatus **1** provides a virtual volume to a host apparatus (not illustrated) which is an upper level device.

The storage apparatus **1** is communicably connected to one or more host apparatuses. The host apparatus and the storage apparatus **1** are connected through communication adapters (CAs) **101** and **102** which will be described below.

The host apparatus, for example, is an information processing apparatus which has a server function, and trans-

mits/receives commands on a NAS and a SAN with respect to the storage apparatus **1**. The host apparatus, for example, transmits a disk access command such as read/write in the NAS with respect to the storage apparatus **1** in order to read/write data from/to the volume provided by the storage apparatus **1**.

Then, the storage apparatus **1** performs a process such as reading/writing of data on an actual storage corresponding to the volume according to an input/output request (for example, a read command and a write command) which is issued from the host apparatus to the volume. In addition, the input/output request from the host apparatus may be referred to as an I/O command or an I/O request.

As illustrated in FIG. **1**, the storage apparatus **1** includes a plurality (two in the embodiment) of controller modules (CM) **100***a* and **100***b* and one or more (one in the example illustrated in FIG. **1**) drive enclosures **30**.

The drive enclosure **30** is mountable with one or more (four in the example illustrated in FIG. **1**) storage devices (physical disks) **31**, and provides the storage areas (actual volume, actual storage) of these storage devices **31** to the storage apparatus **1**.

For example, the drive enclosure **30** includes a plural stages of slots (not illustrated), and the capacity of the actual volume can be changed at any time by inserting the storage devices **31** such as a hard disk drive (HDD) and a solid state drive (SSD) into these slots. Further, redundant arrays of inexpensive disks (RAID) may be formed using the plurality of storage devices **31**.

The drive enclosure **30** is connected to device adapters (DAs) **103** and **103** of the CM **100***a*, and DAs **103** and **103** of the CM **100***b*. Therefore, any of the CMs **100***a* and **100***b* can access the drive enclosure **30** to perform the writing/reading of data. In other words, the respective CMs **100***a* and **100***b* are connected to the storage devices **31** of the drive enclosure **30**, so that the access paths to the storage devices are redundantly formed.

A controller enclosure **40** includes one or more (two in the example illustrated in FIG. **1**) CMs **100***a* and **100***b*.

The CMs **100***a* and **100***b* are controllers (storage control apparatuses) which control the operations in the storage apparatus **1**, and perform various types of control such as access control to the storage device **31** of the drive enclosure **30** according to the I/O command transmitted from the host apparatus. Further, the CMs **100***a* and **100***b* have substantially the same configuration. Hereinafter, as a symbol for indicating the CM, when there is a need to specify one of a plurality of CMs, the symbols **100***a* and **100***b* will be used, and when any CM is indicated, the symbol **100** will be used. Further, the CM **100***a* may be represented by CM #1, and the CM **100***b* by CM #2.

Further, in the drawings, the same symbols as those described above indicate the identical or similar portions, and thus the descriptions thereof will not be repeated.

The CMs **100***a* and **100***b* are configured in pair, and the CM **100***a* performs various types of control under normal conditions as a primary CM. However, when the primary CM **100***a* fails in its operation, the secondary CM **100***b* takes over the operation from the primary CM **100***a*.

The CMs **100***a* and **100***b* each are connected to the host apparatus through the CAs **101** and **102**. Then, the CMs **100***a* and **100***b* receive commands such as read/write which are transmitted from the host apparatus, and performs control on the storage device **31** through the DA **103** or the like. Further, the CMs **100***a* and **100***b* are connected to each other through an interface (not illustrated) such as PCI Express.

As illustrated in FIG. **1**, the CM **100** includes the CAs **101** and **102** and a plurality (two in the example illustrated in FIG. **1**) of the DAs **103** and **103**, and further includes a central processing unit (CPU) **110**, a memory **106**, an SSD **107**, and an IOC **108**.

The CAs **101** and **102** receive data transmitted from the host apparatus and the like, or transmits data out of the CM **100** to the host apparatus and the like. In other words, the CAs **101** and **102** controls data input/output (I/O) with respect to an external apparatus such as the host apparatus.

The CA **101** is a network adapter which is communicably connected to the host apparatus through the NAS; for example, there is a local area network (LAN) interface and the like.

The CM **100** is connected to the host apparatus and the like by the NAS through a communication line (not illustrated) connected to the CA **101**, and performs an I/O command reception and a data transmission/reception. In the example illustrated in FIG. **1**, each of the CMs **100***a* and **100***b* includes two CAs **101** and **101**.

The CA **102** is a network adaptor which is communicably connected to the host apparatus through the SAN; for example, there is an iSCSI interface and a fibre channel (FC) interface.

The CMs **100** are connected to the host apparatus and the like by the SAN through the communication line (not illustrated) connected to the CA **102**, and perform the I/O command reception and the data transmission/reception. In the example illustrated in FIG. **1**, each of the CMs **100***a* and **100***b* includes one CA **102**.

The DA **103** is an interface which is communicably connected to the drive enclosure **30**, the storage device **31** and the like. The DA **103** is connected to the storage devices **31** of the drive enclosure **30**, and each CM **100** performs the access control to the storage devices **31** based on the I/O command received from the host apparatus.

The CM **100** performs data write/read on the storage device **31** through the DA **103**. Further, in the example illustrated in FIG. **1**, each of the CMs **100***a* and **100***b* includes two DAs **103** and **103**. Then, in each of the CMs **100***a* and **100***b*, each DA **103** is connected to the drive enclosure **30**.

With this configuration, any one of the CMs **100***a* and **100***b* can perform data write/read on the storage device **31** of the drive enclosure **30**.

The SSD **107** is a storage device which stores a program executed by the CPU **110** and various types of data.

The memory **106** is a storage device which temporarily stores various types of data and a program, and includes a memory area and a cache area which are not illustrated. The cache area temporarily stores data received from the host apparatus and data to be transmitted to the host apparatus. The memory area is used to temporarily store and develop the data and the program when the CPU **110** executes the program.

The input output controller (IOC) **108** is a control device which controls data transmission in the CM **100**, and for example realizes DMA (Direct Memory Access) transfer in which the data stored in the memory **106** is transferred without passing through the CPU **110**.

The CPU **110** is a processing device which performs various types of control and calculations, and for example there is a multi-core processor (multi-CPU). The CPU **110** executes the OS and the program stored in the SSD **107** and the like, thereby realizing various functions.

The CPU **110** executes a hypervisor **200** which is a virtualization OS, and executes a plurality of virtual

machines (VMs) on the hypervisor, thereby causing a plurality of OSs to be executed. Hereinafter, an OS executed on the hypervisor **200** may be referred to as a guest OS or a GOS.

A plurality of guest OSs can share hardware resources such as the CPU **110**, the memory **106**, and the SSD **107**.

In addition, a plurality of CPUs **110** may be provided and the hypervisor **200** may be performed on the plurality of CPUs **110**.

FIG. **2** is a diagram schematically illustrating a plurality of OSs on the hypervisor **200** in the storage apparatus **1** according to the embodiment.

In the embodiment, as illustrated in FIG. **2**, a SAN OS **400** and a NAS OS **300** are executed on the hypervisor **200**.

The SAN OS **400** is an OS for performing SAN control, and includes a kernel **401** and a function firmware **402**. Various types of existing OSs can be used as the SAN OS **400**, but VxWorks (registered trademark) made by Wind River will be exemplified in the embodiment.

The NAS OS **300** is an OS for performing NAS control, and includes a kernel **301** and a function firmware **302**. Various types of existing OSs can be used as the NAS OS **300**, but Linux (registered trademark) will be exemplified in the embodiment.

Then, the CPU **110** functions as the hypervisor **200**, the SAN OS **400**, and the NAS OS **300** by executing a storage control program.

In addition, a program (storage control program) for realizing the functions as the hypervisor **200**, the SAN OS **400**, and the NAS OS **300**, for example, is provided in types of being recorded in a computer-readable recording medium such as a flexible disk, a CD (such as a CD-ROM, a CD-R, and a CD-RW), a DVD (such as a DVD-ROM, a DVD-RAM, a DVD-R, a DVD+R, a DVD-RW, a DVD+RW, and an HD DVD), a Blu-ray disk, a magnetic disk, an optical disk, a magneto-optical disk, and the like. In this case, the computer reads the program from the recording medium, and transfers and stores the program into an inner storage unit or an external storage unit for use. While being stored in a storage apparatus (recording medium) such as the magnetic disk, the optical disk, and the magneto-optical disk, the program may be provided to a processor **10** from the storage apparatus through a communication path. Further, the program may be recorded in a storage device (recording medium), for example, a magnet disk, an optical disk, a magneto-optical disk, and the like, and provided to the computer from the storage device through a communication path.

When the functions as the hypervisor **200**, the SAN OS **400**, and the NAS OS **300** are realized, the program stored in an internal storage device (the memory **106** and the SSD **107** in the embodiment) is executed by a microprocessor (the CPU **110** in the embodiment) of the computer. At this time, the program stored in the recording medium may be read by the computer for execution.

FIG. **3** is a diagram schematically illustrating a functional configuration of the NAS OS **300** and the SAN OS **400** on the hypervisor **200** in the storage apparatus **1** according to the embodiment.

As illustrated in FIG. **3**, the NAS OS **300** includes Samba/NFS server software **350**, a file system **340**, an OS system controller **390**, and an SCSI driver group **360**.

On the other hand, the SAN OS **400** includes an intelligent CA agent **410**. Further, an inter-GOS communication unit **500** is provided to connect the NAS OS **300** and the SAN OS **400**.

The Samba/NFS server software **350** is a file system-based application, which uses Samba or NFS to receive the I/O request of the NAS received from the host apparatus and transfers the request to the file system **340**.

The file system **340**, for example, is a virtual file system (VFS) or a file system such as ext3, which converts the I/O request received from the Samba/NFS server software **350** into an API of every relative local file system and transfers the API to the SCSI driver group **360**.

The OS system controller **390** performs various types of normal control as the NAS OS, and for example issues an event request such as additional request of the device to the SCSI driver group **360** (an LLD **310**).

The SCSI driver group **360** includes a plurality of drivers for controlling SCSI devices.

As illustrated in FIG. **3**, the SCSI driver group **360** has a layered architecture which is configured of 3 layers such as an upper level driver (ULD; upper level layer) **330**, a middle level driver (MLD; middle level layer) **320**, and a lower level driver (LLD; lower level layer) **310**.

The ULD **330** includes a highest level interface for types of kernels and primary devices of the SCSI.

In the ULD **330**, four types of drivers such as an SD, an SR, an ST, and an SG are prepared, and these drivers are differently used depending on the types of SCSI devices. Herein, the SD is used at the time of access to a HDD, and has a block type. The SR is used at the time of access to a CD-ROM, and has a block type. The ST is used at the time of access to a tape device, and has a block type. The SG is a pseudo host adapter which is used without a host bus adapter (hardware), and has a character type.

The MLD **320** provides an SCSI driver API (Application Programming Interface, library) for the ULD **330** and the LLD **310**. The SCSI driver reads the MLD **320** to perform control.

The LLD **310** includes an actual driver corresponding to a physical interface which is applicable to the SCSI, and corresponds to the host bus adapter. The LLD **310** is a driver layer which controls a hardware interface, and the driver to be used is unique for every device. For example, as illustrated in FIG. **5**, the LLD **310** includes an iSCSI driver **313** and an FC driver **312**. Furthermore, in the storage apparatus **1**, the LLD **310** includes an intelligent SCSI driver **311**. In addition, an existing Linux driver may be used for the ULD **330** and the MLD **320**.

As illustrated in FIG. **3**, in the NAS OS **300**, the I/O request from the host apparatus reaches the intelligent SCSI driver **311** of the LLD **310** through the Samba/NFS server software **350**, the file system **340**, the ULD **330**, and the MLD **320**.

The intelligent SCSI driver **311** receives the I/O request from the file system **340**, and transmits the I/O request to the intelligent CA agent **410** in the SAN OS **400** through the inter-GOS communication unit **500** to be described below. In addition, the I/O request receives the request in a format of an SCSI command in the intelligent SCSI driver **311**.

Further, the intelligent SCSI driver **311** receives a response (result) to the transmitted SCSI command from the intelligent CA agent **410**, and informs the ULD **330** of the SCSI driver layer **360** about the received result.

When receiving the I/O request of the NAS from the host apparatus and the like, the intelligent SCSI driver **311** suppresses a direct access to a SAN-dedicated volume **501** (see FIG. **5**) and transmits the I/O request of the NAS to the SAN OS **400** by inter-guest communication through the inter-GOS communication unit **500** to be described.

Furthermore, the intelligent SCSI driver **311** processes the event request for the device which is received from the OS system controller **390** of the NAS OS **300**. For example, in a case where the event request is a request for adding a device, the intelligent SCSI driver **311** receives the addition request and adds (defines) a device file in the folder "/dev".

The inter-GOS communication unit **500** transmits or receives data between the guest OSs. In the storage apparatus **1**, the data is transmitted or received between the NAS OS **300** and the SAN OS **400**. Specifically, the I/O request (SCSI command) received in the NAS OS **300** is transferred from the intelligent SCSI driver **311** to the intelligent CA agent **410** of the SAN OS **400**.

Further, the inter-GOS communication driver **510** transfers a response (result) to the I/O request from the intelligent CA agent **410** of the SAN OS **400** to the intelligent SCSI driver **311** of the NAS OS **300**.

FIG. **4** is a diagram for describing inter-GOS communication in the storage apparatus **1** according to the embodiment.

The inter-GOS communication unit **500** controls communication between the guest OSs through the inter-GOS communication driver **510** which is provided in each of the SAN OS **400** and the NAS OS **300**.

Further, the inter-guest OS communication uses a shared memory **520** (see FIG. **9**) shared between the NAS OS **300** and the SAN OS **400** and an interrupt of an inter-processor interrupt (IPI) scheme. The IPI controls an interrupt between the guest OSs through the hypervisor **200**.

In other words, the inter-GOS communication driver **510** of the guest OS on the data transmission side writes information (data) indicating a request to transmit data to a predetermined area (for example, a control area for transferring a request) of the shared memory **520**. Then, an interrupt is informed to the inter-GOS communication driver **510** of the guest OS at the transmission destination using the IPI function through the hypervisor **200**. The inter-GOS communication driver **510** which receives the interrupt reads the area in the shared memory **520** to make preparation for the reception of transmission data. Therefore, the data transmission/reception (communication) between the guest OSs is completed.

Further, in actual data transmission, data transmission between the cache area and each guest OS area in the shared memory **520** is realized by the DMA transfer function of the IOC **108** described above. REQUEST/RESPONSE as exchange of control information for transmitting and receiving the data are realized using the shared memory **520** and the interrupt of the IPI scheme.

In the example illustrated in FIG. **4**, a thick broken line represents an IPI notification from the NAS OS **300** to the SAN OS **400**, and a thick solid line represents the IPI notification from the SAN OS **400** to the NAS OS **300**.

In the example illustrated in FIG. **4**, in the NAS OS **300**, the OS system controller **390** and the intelligent SCSI driver **311** instruct the inter-GOS communication driver **510** to transmit data, and receive a response from the inter-GOS communication driver **510**. On the other hand, in the SAN OS **400**, an intelligent CA agent **410** and a system controller **419** instruct the inter-GOS communication driver **510** to transmit data, and receive a response from the inter-GOS communication driver **510**.

Further, when the data is transmitted from the SAN OS **400** to the NAS OS **300**, the hypervisor **200** handles an interrupt by the IPI, and informs the NAS OS **300**. However, when the data is transmitted from the NAS OS **300** to the SAN OS **400**, a direct interruption scheme is used to directly inform the SAN OS **400** without passing through the hypervisor **200** as denoted by arrows **A01** and **A02** in FIG. **4**. The direct interrupt is an interrupt notification between the guest OSs without passing through the hypervisor **200**.

With this configuration, it is possible to speed up the data transmission (inter-guest communication) from the NAS OS **300** to the SAN OS **400**.

FIG. **5** is a diagram illustrating a detailed functional configuration of the NAS OS **300** and the SAN OS **400** on the hypervisor **200** of the storage apparatus **1** according to the embodiment.

As illustrated in FIG. **5**, the NAS OS **300** includes the SCSI driver layer **360**, the file system **340**, the Samba/NFS server software **350**, a SCSI application **370**, and a network layer **380**.

The network layer **380** controls communication in a network layer, for example, receives the I/O request of the NAS from the host apparatus.

The SCSI driver layer **360** is a driver group for controlling the SCSI devices, and corresponds to the SCSI driver group **360** illustrated in FIG. **3**.

In the NAS OS **300**, an I/O control request is issued to the SCSI driver layer **360** through the file system **340**.

In the SCSI driver layer **360**, an SCSI disk driver corresponds to the ULD **330** illustrated in FIG. **3**, and a common service corresponds to the MLD **320**.

Further, the SCSI driver layer **360** includes the iSCSI driver **313** and the FC driver **312** which correspond to the above-mentioned LLD **310**. The functions of the respective components as the NAS OS **300** are well known in Linux and the like for example, and thus the detailed descriptions thereof will not be made.

Then, in the storage apparatus **1**, the LLD **310** of the SCSI driver layer **360** includes the above-mentioned intelligent SCSI driver **311**.

As illustrated in FIG. **5**, the SAN OS **400** includes an intelligent CA driver **420**, a target driver **430**, a CA thread **440**, a basic control **450**, a backend control **460**, an FC-CA driver **425**, an iSCSI-CA driver **424**, and a SAS-CA driver **423**.

In addition, among these components, the functions as the target driver **430**, the CA thread **440**, the basic control **450**, the backend control **460**, the FC-CA driver **425**, the iSCSI-CA driver **424**, and the SAS-CA driver **423** are well known in the SAN OS **400** such as VxWorks, and thus the descriptions thereof will not be made.

The intelligent CA driver **420** is a virtual driver layer of the NAS which is added to a channel adapter driver layer of the SAN control in the SAN OS **400**. The intelligent CA driver **420** performs the I/O request and a response transmission/reception of the NAS with respect to the NAS OS **300**. The intelligent CA driver **420** includes an SCSI command queue **421** and an SCSI status queue **422**.

For example, the I/O command received from the NAS OS **300** is stored in the SCSI command queue **421**, and status information and the like as a response to the NAS OS **300** is stored in the SCSI status queue **422**.

The target driver **430** includes the intelligent CA agent **410**. The intelligent CA agent **410** is a NAS-dedicated function which is added to the target driver **430**, and is a block which controls the I/O request received from the NAS OS **300** through the inter-guest OSs communication. The intelligent CA agent **410** may be called a NAS control block **441***b*. The function of the intelligent CA agent **410** (the NAS control block **441***b*) will be described below.

The CA thread **440** includes an optimized NAS I/O layer **451**. The optimized NAS I/O layer **451** is used for process-

ing the I/O request from the NAS OS **300**, and obtained by customizing the CA thread (including the CA driver) of the SAN. The optimized NAS I/O layer **451** may be called the CA control block **441***a*. The function of the optimized NAS I/O layer **451** (the CA control block **441***a*) will be described below.

Furthermore, one or more SAN-dedicated volumes **501** and NAS-dedicated volumes **502** are provided on the hypervisor **200**. The SAN-dedicated volumes **501** are storage areas in which the I/O request by the SAN is performed, and the NAS-dedicated volumes **502** are storage areas in which the I/O request by the NAS is performed. In other words, the SAN-dedicated volumes **501** and the NAS-dedicated volumes **502** are guest OS-dedicated volumes.

The SAN-dedicated volumes **501** and the NAS-dedicated volumes **502**, for example, are set and managed by a management apparatus (not illustrated), and a management screen and the like thereof are displayed on a display of the management apparatus.

FIG. **6** is a diagram illustrating a volume creation screen **800** in the storage apparatus **1** according to the embodiment.

In the storage apparatus **1**, various types of management screens are displayed on the display of the management apparatus. For example, the volume creation screen **800** as illustrated in FIG. **6** is displayed when a volume is created. A manager operates an input device such as a mouse and a keyboard (not illustrated) to input various types of information in the volume creation screen **800**, so that the SAN-dedicated volume **501** and the NAS-dedicated volume **502** are created.

The management screen displayed on the display of the management apparatus, for example, may be created and displayed by the management apparatus, or the CPU **110** and the like of the primary CM **100** may perform these processes.

In the example illustrated in FIG. **6**, the volume creation screen **800** includes input areas **801** to **804**. For example, an arbitrary volume name of a volume to be created can be input in the input area **801**. An arbitrary RAID type of the volume to be created can be input in the input area **802**. In the example illustrated in FIG. **6**, any one of RAID 1 to RAID 6 can be selected in a pull-down menu.

An arbitrary size of the volume to be created can be input in the input area **803**. Further, an arbitrary attribute of the volume to be created can be input in the input area **804**. For example, in the example illustrated in FIG. **6**, any one of a SAN volume and a NAS volume can be selected as an attribute, and any one of "Normal", "Thin provisioning", and "Copy" can be further selected as the SAN volume.

For example, in a case where any one of "SAN Normal", "SAN Thin provisioning", "SAN Copy" is selected as the volume attribute, the SAN volume can be created, and when "NAS" is selected, the NAS volume can be created.

When a create button **805** is selected after the input areas **801** to **804** are input with each piece of information, the I/O request instructing to create the volume is transmitted to the SAN OS **400** for example.

Further, the storage apparatus **1** can selectively create the SAN volume and the NAS volume in one volume creation screen **800**. In other words, the SAN volume and the NAS volume can be managed and operated through one management screen, and the convenience increases.

FIG. **7** is a diagram schematically illustrating a functional configuration of the SAN OS **400** in the storage apparatus **1** according to the embodiment.

The SAN OS **400** includes a NAS agent **441** which processes the I/O request from the NAS OS **300**.

The NAS agent **441** processes a NAS input/output request which is received from the intelligent SCSI driver **311**.

The NAS agent **441** includes the NAS control block **441***b* which controls the I/O request from the NAS OS **300**, and the CA control block **441***a* which processes the I/O request.

The intelligent CA agent **410** illustrated in FIG. **5** functions as the NAS control block **441***b*, or the optimized NAS I/O layer **451** illustrated in FIG. **5** functions as the CA control block **441***a*. In other words, the intelligent CA agent **410** and the optimized NAS I/O layer **451** function as the NAS agent **441**.

The NAS control block **441***b* controls the I/O request which is received from the NAS OS **300** through the inter-GOS communication unit **500**.

For example, the NAS control block **441***b* has a function of logging in to a virtual host (dummy host) so as to process the request from the NAS OS **300** in the SAN OS **400**, and informs the CA control block **441***a*.

Further, the NAS control block **441***b* analyzes and checks the SCSI command from the NAS OS **300** and informs the CA control block **441***a*.

As the SCSI command which is supportable in the NAS control block **441***b*, the following commands are exemplified.

READ6(10), WRITE6(10), READ CAPACITY(16), SYNCHRONIZE CACHE, TEST UNIT READY, INQUIRY(Standard, Page 00, 80, 83, 86, 8F, B0, B2, F0, F1, F2) and MODE SENSE (page 00, 01, 02, 03, 04, 07, 08, 0A, 1C).

In addition, for example, the number written in the parenthesis "( )" in these commands shows various types of parameters such as a bit number and a page number, and various modifications can be made.

Further, the NAS control block **441***b* sends a request to the IOC **108** for the data transmission and data integrity field (DIF) control between the cache area and the NAS OS area in the shared memory **520** through a serial attached SCSI (SAS) driver for example according to a transmission request content from the CA control block **441***a* as described below.

The CA control block **441***a* processes the I/O request which is received from the NAS OS **300** through the inter-GOS communication unit **500**. The CA control block **441***a* has the following functions.

In other words, an NIC (Network Interface Card) mounting port area in a port management area is released to the NAS control block **441***b*, and a command management such as queue management and block control is performed.

Further, the CA control block **441***a* informs the basic control **450** (see FIG. **5**) of a command and an event which are created by the NAS control block **441***b*. Furthermore, when the data transmission is requested from the basic control **450**, the NAS control block **441***b* is called to perform a process according to the processing result. In other words, an abnormal sense creation, a transmission request and the like are performed.

In addition, a resource/cache **480** in FIG. **7** corresponds to the basic control **450** in FIG. **5**. Further, a maintenance unit **470** is a maintenance controller which performs control of a maintenance system in the storage apparatus **1**.

An exemplary process in the storage apparatus **1** according to the embodiment as configured above will be described according to a flowchart illustrated in FIG. **8**. In addition, in FIG. **8**, a read command of the NAS is exemplified.

When the read request of the NAS is performed, the intelligent SCSI driver **311** in the NAS OS **300** prepares a read data storage area in the NAS area of the shared memory **520** in Step A**1**.

In Step A**2**, the read command is informed from the intelligent SCSI driver **311** of the NAS OS **300** to the intelligent CA driver **420** of the SAN OS **400** through the inter-GOS communication unit **500** (inter-GOS communication). In addition, since the inter-GOS communication is performed in a direct interrupt scheme without passing through the hypervisor **200**, it is possible to reduce time necessary for the communication.

In Step A**3**, the intelligent CA driver **420** receives the read command. In this way, the inter-GOS communication is performed between the NAS OS **300** and the SAN OS **400**.

In Step A**4**, the intelligent CA driver **420** analyzes the received command and determines that the command is the read command. The read command is passed through the CA thread **440** (Step A**5**), and in Step A**6**, a cache area is acquired by the resource/cache **480**.

In Step A**7**, the resource/cache **480** arranges read data in the acquired cache area, and the cache area comes to be a state where the read data is ended in arrangement (Step A**8**). The fact that the read data is arranged in the cache area is informed through the CA thread (Step A**9**) to the intelligent CA driver **420**.

In Step A**10**, the intelligent CA driver **420** makes a request to the IOC **108** for the data transmission, a block check character (BCC) check, and the added BCC removal. When the IOC **108** performs these processes, the read data in the cache area is stored in the read data storage area secured by the intelligent SCSI driver **311** in Step A**1** (Step A**12**).

Further, the IOC **108** informs the intelligent CA driver **420** of the completion (Step A**13**), and the intelligent CA driver **420** informs the intelligent SCSI driver **311** of the completion through the inter-GOS communication unit **500** (inter-GOS communication) in Step A**14**. At this time, the inter-GOS communication is performed between the SAN OS **400** and the NAS OS **300**.

Next, a creating process of the NAS-dedicated volume **502** (see FIG. **5**) in the storage apparatus **1** according to the embodiment will be described according to a flowchart illustrated in FIG. **9** (Steps B**1** to B**10**).

The creating process of the NAS-dedicated volume **502** is performed by selecting the create button **805** in a state where "NAS" is selected as an attribute in the input area **804** in the volume creation screen **800** illustrated in FIG. **6**.

In Step B**1**, various types of information input to the volume creation screen **800** are analyzed in the SAN OS **400**, and the creating process of the SAN volume is performed based on the information in Step B**2**. In Step B**3**, the created SAN volume is formatted.

Thereafter, in Step B**4**, a process of changing the attribute of the created SAN volume to the NAS volume is performed, the information (for example, attribute information, size, and the like) of the created volume is stored in a database of configuration information in the SSD **107**.

In Step B**6**, inter-GOS communication interface conversion control is performed, a volume number of the volume created in Step B**2** is informed to the NAS OS **300** along with an instruction to create the NAS volume through the shared memory **520** by the inter-GOS communication.

In the NAS OS **300**, first, a device is created based on the volume number according to the instruction to create the NAS volume informed by the inter-GOS communication in Step B**7**, and the device is registered (/dev). Therefore, the volume created in the SAN is recognized as hardware usable for the NAS OS **300**.

Further, a partition is created for the created volume in Step B**8**, a mount point is created in Step B**9**, and the file system is formatted in Step B**10**.

Thereafter, the completion is informed to the SAN OS **400**, completion/return of the screen is performed in the SAN OS **400** (Step B**11**), and the process is ended.

In addition, the example illustrated in FIG. **9** illustrates a case where a process request input in the volume creation screen **800** is processed in the SAN OS **400** and transferred to the NAS OS **300** through the inter-GOS communication unit **500** to be processed in the NAS OS **300**, but the invention is not limited thereto.

In other words, the process request input in the input screen, through which the process request of the NAS and the process request of the SAN can be input, may be processed in the NAS OS **300**, and then transferred to the SAN OS **400** through the inter-GOS communication unit **500** to be processed in the SAN OS **400**, and may be processed in various modified manners.

As described above, with the storage apparatus **1** according to the embodiment, the hypervisor **200** which is the virtualized OS is executed on the CPU **110** which is the multi-core processor, and the NAS OS **300** and the SAN OS **400** are executed on the hypervisor **200**. Therefore, the file system control implemented in a dedicated server apparatus in the related art can be mounted in the storage apparatus **1** as the guest OS. Accordingly, it is possible to reduce a cost for introducing the server apparatus.

In the NAS OS **300**, when receiving the I/O request of the NAS from the host apparatus and the like, the intelligent SCSI driver **311** suppresses the direct access to the SAN-dedicated volume **501** and transmits the I/O request of the NAS to the SAN OS **400** by the inter-guest OS communication through the inter-GOS communication unit **500**.

At this time, since the inter-guest OS communication is performed by the direct interrupt scheme without passing through the hypervisor **200**, it is possible to reduce time necessary for the communication.

In the SAN OS **400**, the intelligent CA driver **420** performs the I/O request of the NAS and transmission/reception of a response with respect to the NAS OS **300**. Thereafter, in the NAS agent **441** of the SAN OS **400**, the NAS control block **441***b* controls the received I/O request, and the CA control block **441***a* processes the I/O request. In this way, the I/O request of the NAS can be processed in the SAN OS **400**, and the NAS and the SAN can be integrally handled.

A response such as the processing result of the I/O request is transmitted from the intelligent CA driver **420** to the intelligent SCSI driver **311** of the NAS OS **300** through the inter-GOS communication unit **500**. The NAS OS **300** transmits the response to the host apparatus.

In other words, the I/O requests of the NAS and the SAN are performed for the storage apparatus **1** without a special change in the functional configuration of the host apparatus, and the processing result can be received.

The NAS OS **300** and the SAN OS **400** are configured to be executed on the hypervisor **200**, and the operation of the NAS and the operation of the SAN are configured to be input using the same menu screen. Further, at this time, the data transmission/reception between the SAN OS **400** and the NAS OS is performed by the inter-GOS communication unit **500**. With this configuration, the NAS OS **300** and the SAN OS **400** can be operated by an integrated user interface, so that the convenience increases and a workload of a system

operation manager is reduced. In other words, both the SAN and the NAS can be integrally designed/managed/maintained using a common user interface screen, so that the convenience increases.

In addition, the disclosed technology is not limited to the above embodiment, and various modifications can be made in a scope not departing from the spirit of the embodiment. The respective configurations and processes of the embodiment can be optionally selected as needed, or can be appropriately combined to each other.

For example, the above-mentioned embodiment illustrates an example in which VxWorks is used as the SAN OS **400** and Linux is used as the NAS OS **300**, but the invention is not limited thereto and various modifications such as using other OSs can be made.

According to the embodiment, the NAS and the SAN can be efficiently integrated in the storage apparatus.

All examples and conditional language recited herein are intended for the pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present inventions have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A storage control apparatus comprising:

a processing unit that functions a SAN operating system which performs SAN control and a NAS operating system which performs NAS control to be operated on a virtualized operating system;

an inter-OS communication unit that transmits and receives data between the NAS operating system and the SAN operating system;

a transmission controller that transmits a NAS input/output request received in the NAS operating system to the SAN operating system through the inter-OS communication unit; and

a NAS request processing unit that processes the NAS input/output request received from the transmission controller in the SAN operating system.

2. The storage control apparatus according to claim **1**, wherein

the SAN operating system includes

a response controller that transmits a response to the NAS input/output request, which is processed by the NAS request processing unit, to the NAS operating system through the inter-OS communication unit.

3. The storage control apparatus according to claim **1**, wherein

the inter-OS communication unit includes

a shared memory shared between the NAS operating system and the SAN operating system, and

a notification unit that informs the SAN operating system or the NAS operating system at a data transmitting destination of an interrupt after the data is written in the shared memory.

4. The storage control apparatus according to claim **1**, wherein

a process request input in an input screen through which a process request of the NAS operating system and a process request of the SAN operating system are acceptable is processed in the SAN operating system or the NAS operating system, and

the result of the process is transmitted to the NAS operating system or the SAN operating system through the inter-OS communication unit.

5. A storage control method comprising:

functioning a SAN operating system which performs SAN control and a NAS operating system which performs NAS control to be operated on a virtualized operating system;

transmitting a NAS input/output request which is received in the NAS operating system to the SAN operating system through inter-OS communication; and

processing the NAS input/output request which is received in the SAN operating system.

6. The storage control method according to claim **5**, wherein

in the SAN operating system,

a response to the processed NAS input/output request is transmitted to the NAS operating system through the inter-OS communication.

7. The storage control method according to claim **5**, wherein

in the inter-OS communication,

data is written in a shared memory shared between the NAS operating system and the SAN operating system, and

an interrupt is informed to the SAN operating system or the NAS operating system at a data transmitting destination.

8. The storage control method according to claim **5**, wherein

a process request input in an input screen through which a process request of the NAS operating system and a process request of the SAN operating system are acceptable is processed in the SAN operating system or the NAS operating system, and

the result of the process is transmitted to the NAS operating system or the SAN operating system through the inter-OS communication.

9. A non-transitory computer-readable recording medium having stored therein a storage control program, wherein

the program causes a computer to perform

functioning a SAN operating system which performs SAN control and a NAS operating system which performs NAS control to be operated on a virtualized operating system,

transmitting a NAS input/output request which is received in the NAS operating system to the SAN operating system through inter-OS communication; and

processing the NAS input/output request which is received in the SAN operating system.

10. The non-transitory computer-readable recording medium having stored therein the storage control program according to claim **9**, wherein

in the SAN operating system,

a response to the processed NAS input/output request is transmitted to the NAS operating system through the inter-OS communication.

11. The non-transitory computer-readable recording medium having stored therein the storage control program according to claim **9**, wherein

in the inter-OS communication,

data is written in a shared memory shared between the NAS operating system and the SAN operating system, and

an interrupt is informed to the SAN operating system or the NAS operating system at a data transmitting destination.

12. The non-transitory computer-readable recording medium having stored therein the storage control program according to claim **9**, wherein

a process request input in an input screen through which a process request of the NAS operating system and a process request of the SAN operating system are acceptable is processed in the SAN operating system or the NAS operating system, and

the result of the process is transmitted to the NAS operating system or the SAN operating system through the inter-OS communication.

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